Name of Organization: University of Wisconsin-Madison

Type of Organization: College or University

Contact Information: Dr. Chin Wu

Civil and Environmental Engineering Department

1269D Engineering Hall

Madison WI 53706

Phone: (608) 263 - 3078 **Extension:**

Fax: (608) 262 - 5199

E-Mail:

Project Title: Dynamic Sediment Transport Modeling in Duluth-Superior Harbo

Project Category: Contaminated Sediments

Rank by Organization (if applicable): 0

Total Funding Requested ($): 129,400 **Project Duration:** 2 Years

Abstract:

The project proposes a real time, dynamic sediment transport model to predict contaminated sediment resuspension, transport, and re-distribution for assisting assessments of sediment remediation options. To address resuspension of highly elevated contaminated sediments in hot spots under habor seiche motions, ship passage, and strong storm condition, a hydrodynamic and wave model will be constructed and implemented to account for current-wave ineteraction. An Eulerian, three-dimensional sediment transport model will be developed to include the effects resulting from wave current interaction, variable bed properties, and flocculation of fine-grained sediments. This sediment transport model will be calibrated with the field measurements. A website consisting of contaminated sediment information and real time data network system will be developed to forecast the distribution of contaminated sediments in the Duluth-Superior Harbor.

Geographic Areas Affected by the Project

States:

- [ ] Illinois
- [ ] Indiana
- [ ] Michigan
- [x] Minnesota
- [ ] New York
- [ ] Pennsylvania
- [x] Wisconsin
- [ ] Ohio

Lakes:

- [x] Superior
- [ ] Huron
- [ ] Michigan
- [ ] Erie
- [ ] Ontario
- [ ] All Lakes

Geographic Initiatives:

- [ ] Greater Chicago
- [ ] NE Ohio
- [ ] NW Indiana
- [ ] SE Michigan
- [ ] Lake St. Clair

Primary Affected Area of Concern: St. Louis River, MN

Other Affected Areas of Concern:

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

Recent investigations (MPCA and WDNR, 1992, Crane et al., 1997, King, 1999) reported that the sediments in Duluth-Superor harbor are highly contaminated with PAHs, PCBs, and heavy metals such as mercury, cadmium and copper. Particularly, the slip C and Minnesota slip near the North Duluth canal connected to Lake Superior had the highest PAH concentration (Crane et al., 1997) appeared to be primarily from historical sources. Similar elevated contaminants are also found at City of Superior WWTP, Hog island near the South Superior Bay entrance. Some observations have suggested that fine-grained cohesive particles absorbing many toxic contaminants in the Duluth-Superior Harbor have a great ability to resuspension under the habor seiche motions, ship passage, and strong episodic storms. While some sediment remediation plans have been proposed, no assessment of how susceptible these sediments are to resuspension or their re-distribution have been conducted. Up to date, knowledge of sediment transport is based primarily on theory and laboratory experiments, however, limited numbers and difficulties in the field studies make verification of theory and laboratory results and extension of those results to the natural environmental difficult. Continuation of a comprehensive study is needed to improve understanding and prediction of cohesive sediment transport and the coupling between contaminants and cohesive particles.

Proposed Work Outcome:

This proposal focuses on modeling resuspension, transport and redistribution of contaminated sediments under various causes of water motions such as harbor oscillations, ship passage, and storm events in the Duluth-Superior Harbor. The outcome of the project will provide a dynamic tool to map the fate and distribution of contaminated sediments in the Harbor and to assist in assessing options and feasibility of sediment remediation plans.

The proposed works consist of the following components:

(1) Real-Time Online Velocity and Water Level Data Collection System

Four current meters will be deployed at Slip C, Miller Creek, City of Superior WWTP, Superior Bay Entry in the Duluth-Superior Harbor. The data will linked to USGS real time stream gage network. A online website will be developed to transfer real time velocity and water level data. This website will also be designed to include foercasting results predicted by the proposed numerical modeling and other contamianted sediment website by MPCA, UW Sea Grant Institute, WDNR, and US Army Corps of Engineers.

(2) Hydrodynamic and Wave Modeling

The fate of chemical contaminants associated with fine-grained bed sediments is controlled primarily by hydrodynamic forcing and sediment composition and, secondarily, by water chemistry. A model acounting for hydrodynamic current and

wave interactions will be constructed and implemented. To have a effient computation and circumvent complicated grid generation due to the irregular harbor geometry, we will use a existing two-dimensional finite element hydrodynamic model. A wave model will be developed to couple with the hydrodynamic model to address the effects of wave-current interactions such as harbor oscillations, ship generated waves, and strong wind storms.

(3) Sediment Transport Modeling

Most of the toxic chemical are sorbed onto and are transported by fine-grained sediments in the Duluth-Superior Harbor. The resuspension, transport, and deposition of these fined-grained contaminated sediment are strongly influenced by sediment properties, bathymetry, and turbulent shear stress induced by wave-current interactions. This project will develop an Eulerian, three-dimensional sediment transport model that includes the effects of wave current interaction in the hydrodynamic-wave model, variable bed properties, and flocculation of fine-grained sediments. Concurrently, we will plan to develop a Langragian-based particle tracking model that can predict sediment particle trajectories and residence time.

(4) Integration Modeling and Data Network

This sediment transport, hydrodynamic, and wave model will be applied to predict contaminated sediment resuspenion, transport, redistribution of the Duluth-Superior harbor area from the upstream Fond Du La site of St. Louis River to the North Duluth Ship canal and the South Superior Bay entrance channel. The real time online data will be linked with the input of the model to forecast sediments transport. The dynamic sediment transport model can provide distribution of contaminated sediment for assisting the short-time or long-term sediment remediation plans or options.

(5) Other issues:

This work is parallel to and will be integrated to the other project that proposes to use an innovative in-situ equipment for the study of resuspension.

Project Milestones:	Dates:
Project Start	10/2000
Current Meters Deployment	11/2000
Real Time Online Data System	03/2001
Construction of Computational Grids	04/2001
Hydrodyanmic-Wave Modeling	10/2002
Sediment Resuspension/Transport Modeling	04/2002
Integration of Modeling and Data Network	07/2002
Final Report	10/2002

☐ Project Addresses Environmental Justice

If So, Description of How:

☒ Project Addresses Education/Outreach

If So, Description of How:

This results of the project develop an real time online sediment transport model that can provide an very effective way to the public outreach. The integration of dynamic sediment transport modeling will be presented to the conference and disseminated through peer-review publications. The investigators will also plan on having a workshop in Duluth and for state and local agencies to discuss the model and some options for remediation plans.

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	35,400	7,070
Fringe:	5,500	2,300
Travel:	4,000	0
Equipment:	10,000	0
Supplies:	3,000	0
Contracts:	35,000	0
Construction:	0	0
Other:	0	0
Total Direct Costs:	92,900	9,370
Indirect Costs:	36,500	0
Total:	129,400	9,370
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

The UW Civil and Environmental Engineering will donate 4 current meters for measuring velocity. Buoys and associacted hardware will be provided by the UW Sea Grant Institute.

Description of Collaboration/Community Based Support:

This project will be conducted under the direction of Professor Chin Wu and John A. Hoopes in the Civil and Environmental Engineering Department at the University of Wisconsin at Madison. Professor Wu will be responsible for modifciation of current meters, development of real time data network, and construction and implementation of Hydrodynamic-Wave-Sediment Models. Professor Hoopes will oversee the in-situ data collection and analysis. Both investigators are directly involved with and committed to the completion of the project.

The installtion of real time online data network will be coordinated with USGS, MPCA, and WDNR. The numerical modeling work will be also linked to the Great Lakes Sediment Transport Program, Nemadji River, Minnesota/Wisconsin Watershed and Tributaries Studies directly by U.S. Army Corps of Engineers, Great Lakes & Ohio River Division